DFT unveils decreasing diatonicity and increasing fragmentation in Debussy's piano music

Ludovica Schaerf[1], Sabrina Laneve[2], Gabriele Cecchetti[1], Johannes Hentschel[1], Martin A. Rohrmeier[1]

ludovica.schaerf@epfl.ch

[1] Digital and Cognitive Musicology Lab, École Polytechnique Fédérale de Lausanne [2] Conservatorio *G. Verdi*, Turin

Introduction

In Debussy's "Impressionist" style, diatonic structures are blended with or replaced by octatonic, whole-tone, or other chromatic structures [1], resulting in fragmented yet coherent constructions [2]. These features highlight the complexities in assessing the composer's relationship with the earlier common practice.

In this study, we propose a quantitative approach to investigating the diachronic evolution of Debussy's style based on a novel corpus comprising the composer's entire solo-piano production (82 pieces in the period 1880-1917). We hypothesise

H1. a decrease over time of diatonicity and a corresponding increase in the **prevalence** of symmetric structures,

H2. an increase in **fragmentation** and, yet,

H3. a non-decreasing overall **coherence**.

Methodology

Given a piece of total duration L, the pitch-class vector (PCV) $x_{o,l} \in \mathbb{R}^{12}_{+}$ encodes the distribution of pitch classes in the segment with onset $o < L$ and length $l \leq L - o$. The **Discrete Fourier Transform** (**DFT**) decomposes PCVs into six distinct components

$$\hat{X}(o,l)[k] = \sum_{p=0}^{11} x_{o,l}[p] e^{-i2\pi p \frac{k}{12}}.$$

The magnitude of each DFT component reflects the saliency of a certain type of pitch-class collection in the given PCV [3]:

1st component:	chromaticity	4th component:	octatonicity
2nd component:	tritonicity	5th component:	diatonicity
3rd component:	augmentedness	6th component:	whole-tonedness

Drawing from representations previously introduced as *wavescapes* [4], we map each segment of a piece into a node $n(o,l)$ of a hierarchical graph, the **summary wavescape** (SW, Figure 1). Each node of the SW is labelled with the index $c_{o,l} = \mathrm{argmax}_k |\hat{X}(o,l)[k]|$ of the DFT component with highest magnitude in the corresponding segment.

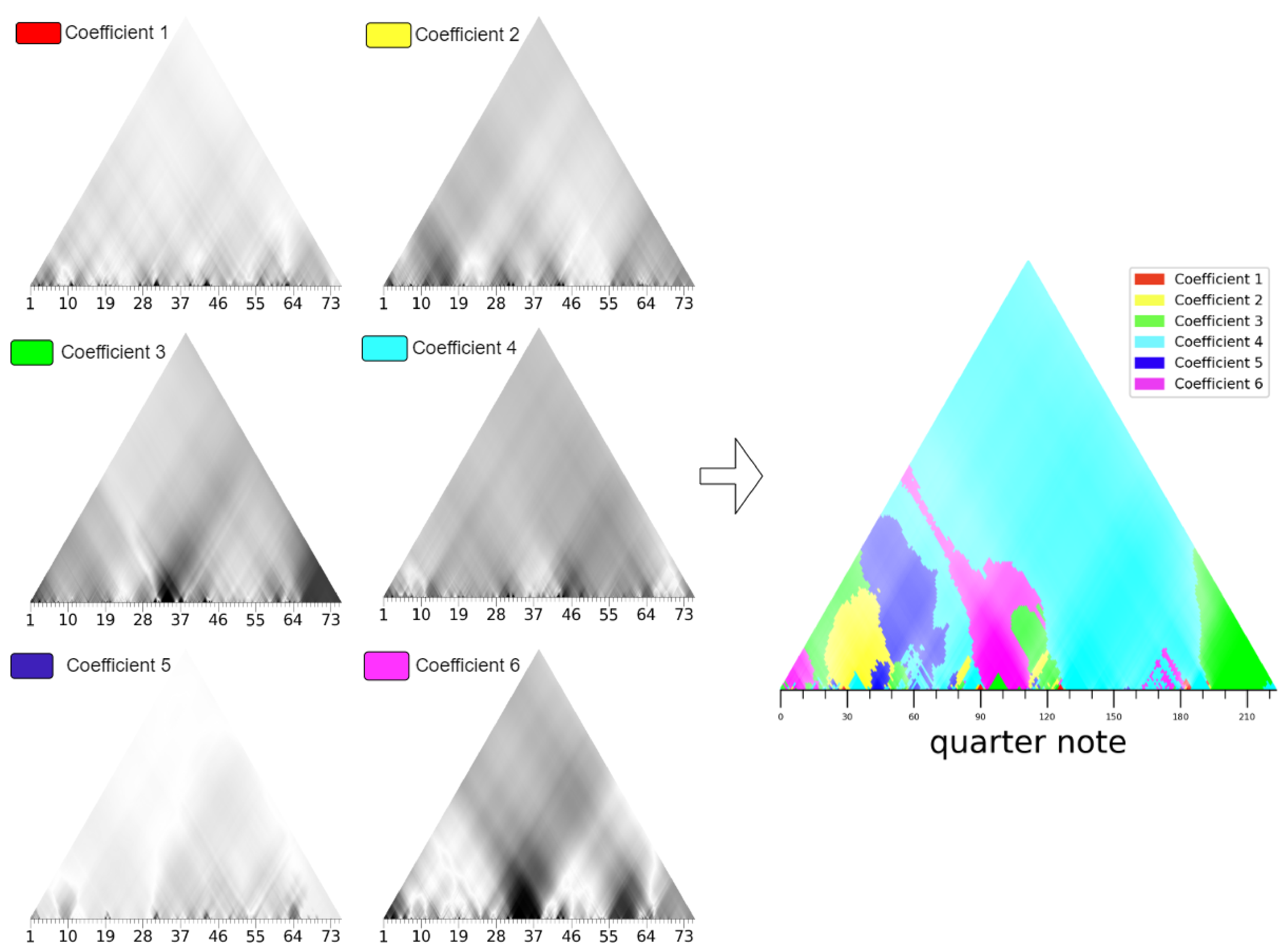

Fig. 1: From Wavescapes to the Summary Wavescape. On the left, the six wavescapes of Ondine (1913) from the Preludes book II, n. VIII. On the right, the summary wavescape of the same piece.

Conclusions

- DFT and wavescapes are employed to bridge qualitative analysis and quantitative distant-listening approaches.
- We find quantitative evidence that Debussy's style underwent an evolution towards alternative forms of tonality.
- Among the "characters" corresponding to DFT components, only octatonicity is found to increase over time.

References

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H1: Prevalence of diatonicity

We weigh each node in the SW by the uncertainty of the distribution of magnitudes across the 6 components $H_{o,l} = 1 - H([|\hat{X}(o,l)|[k]]_k)$ where $H(\cdot)$ is the normalised Shannon entropy. We then define the **prevalence** of DFT component k in a piece as the weighted proportion of the SW's nodes where the k^{th} component has the highest magnitude:

$$W(k) = \frac{1}{N} \sum_{o,l} H_{o,l} \cdot \delta_{c_{o,l},k}.$$

The Bayesian mixed-effects model

$$W(k) \sim Year \times k \times L + (1 + L|Piece)$$

shows significantly **decreasing diatonicity** (5th component) and **increasing octatonicity** (4th component) over time (Figure 2).

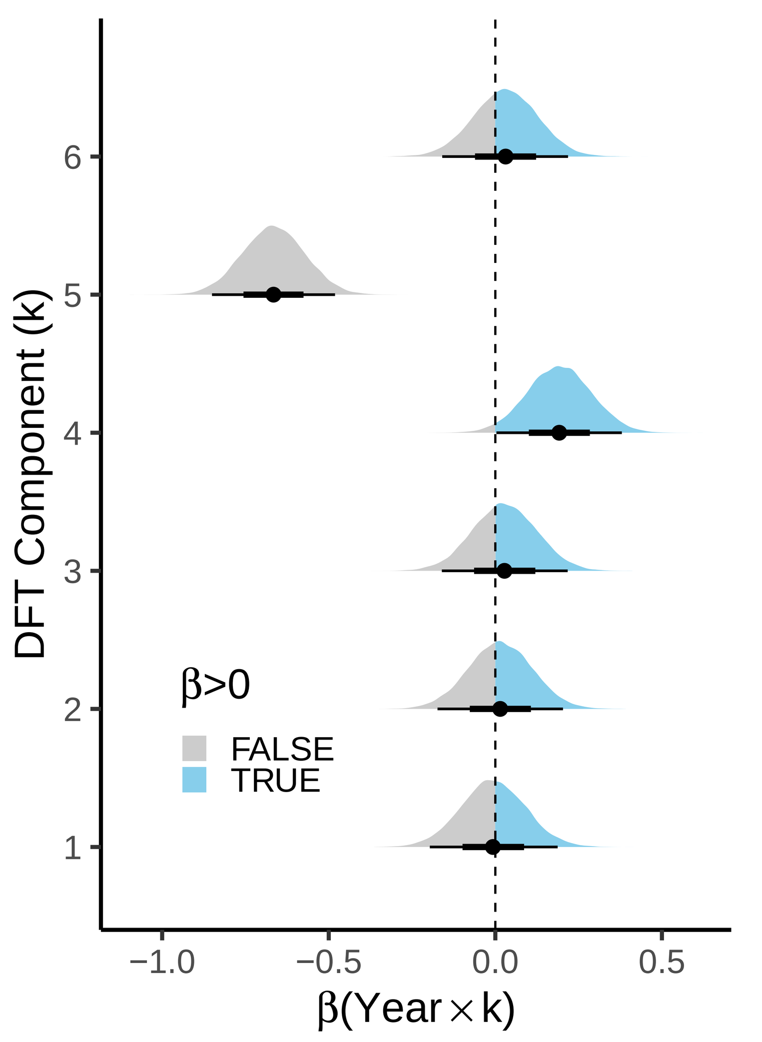


Fig. 2: Posterior distribution of the Year's effect β on the prevalence of each DFT component.

H2: Fragmentation

We define $A = \{A_i\}_i$ as the partition of the SW into sets of neighbouring nodes with identical labels. We then define the **degree of fragmentation** as the entropy

$$H = -\sum_A \frac{\mu(A_i) \log \mu(A_i)}{\log |SW|},$$

where

$$\mu(A_i) = \frac{|A_i|}{|SW|}.$$

The Bayesian regression $H \sim Year \times L$ provides strong evidence that **fragmentation increases** over time (Figure 3).

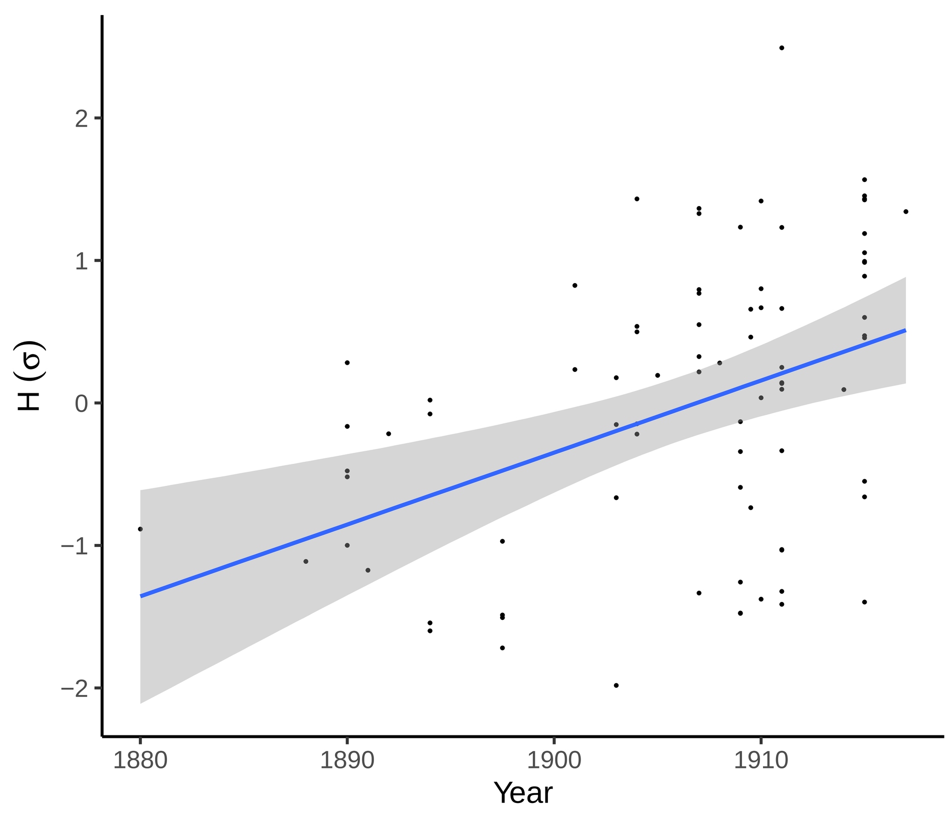


Fig. 3: The composition year's positive effect on fragmentation.

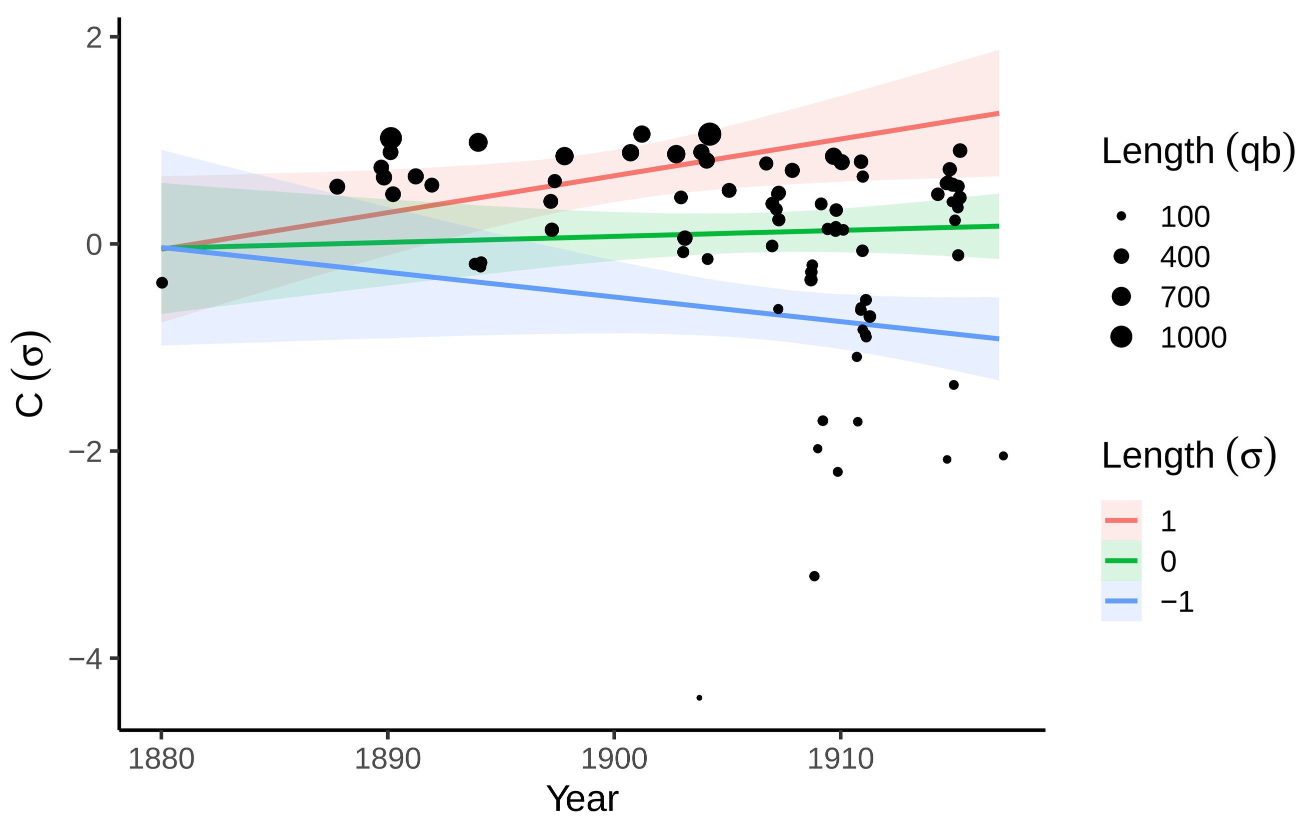
H3: Coherence

We consider a piece as being coherent if even its largest segments are organized according to some pitch structure, i.e., if at least one DFT component remains relatively high in magnitude as we move from shorter to longer segments of the piece. Formally, we define the **coherence** of a piece as the slope C that optimizes the linear fit

$$V_l = C \cdot l + c, \quad \text{where } V_l = \frac{\sum_o \max_k |\hat{X}(o,l)[k]|}{L - l}$$

The Bayesian regression $C \sim Year \times L$ shows **no variation in coherence** over time for pieces of average length, while the significant interaction term indicates that the effect of Year on coherence is more positive for long than for short pieces (Figure 4).

Fig. 4: The composition year's effect on coherence for pieces of average (green), 1σ lower-than average (blue), and 1σ higher-than-average (red) length.



Acknowledgements

Funded by the SNSF and the European Research Council under the European Union's Horizon 2020 research and innovation programme under grant agreement No 760081 – PMSB.